Patent Claims

1. Method of thermally treating disk-shaped substrates, especially semiconductor wafers, in a rapid heating unit having at least one first radiation source, which is spaced from the substrate, for heating at least one substrate, whereby the substrate is heated in a heating phase and is cooled in a subsequent cooling phase, characterized in that the substrate, at least during a portion of the cooling phase, is supported at a distance between 50µm and 1mm from a heating/cooling plate.

2. Method according to claim 1, characterized in that the distance is between 150 and 50µm.

3. Method according to claim 1 or 2, characterized in that the substrate is supported in the rapid heating unit by ultrasonic levitation during the thermal treatment.

4. Method according to one of the preceding claims, characterized in that the heating/cooling plate has at least one first ultrasonic electrode.

5. Method according to claim 4, characterized in that the first ultrasonic electrode has at least one flat radiation surface that essentially corresponds to the shape and size of the substrate.

6. Method according to claim 5, characterized in that the first ultrasonic electrode has at least one radiation surface that is inclined relative to the flat radiation surface and by means of which the substrate is supported in a prescribed lateral position.

7. Method according to one of the claims 3 to 6, characterized in that at least one second ultrasonic electrode is provided that is angled and/or movable relative to the first ultrasonic electrode.

8. Method according to claim 7, characterized in that the substrate is supported by the second ultrasonic electrode in a prescribed lateral position.

9. Method according to one of the preceding claims, characterized in that the substrate is supported during an initial portion of the heating/cooling phase at a distance of between 50μm and 1mm from the heating/cooling plate, and during the following portion of the cooling phase is supported at a greater distance from the heating/cooling plate.

10. Method according to claim 9, characterized in that the substrate is supported at a distance of between 50µm and 1mm from the heating/cooling plate until it has essentially reached the temperature of the heating/cooling plate.

11. Method according to one of the preceding claims, characterized in that the heating/cooling plate has a thermal mass that is considerably greater than that of the substrate.

12. Method according to one of the preceding claims, characterized in that the temperature of the heating/cooling plate is controlled.

13. Method according to one of the preceding claims, characterized in that the heating/cooling plate is essentially transparent for the radiation of the radiation source.

14. Method according to claim 13, characterized in that for the heating of the heating/cooling plate, a fluid that is essentially opaque for the radiation of the radiation source is introduced into a chamber of the heating/cooling plate.

15. Method according to claim 13, characterized in that during a direct radiation heating of the substrate by the radiation source,

a fluid that is essentially transparent for the radiation thereof is introduced into a chamber of the heating/cooling plate.

16. Method according to claim 10, characterized in that for the cooling of the heating/cooling plate, a fluid is conveyed through a chamber of the heating/cooling plate.

17. Method according to one of the preceding claims, characterized in that the heating/cooling plate is essentially opaque for thermal radiation originating from the substrate.

18. Method according to one of the preceding claims, characterized in that at least a second radiation source is provided on that side of the heating/cooling plate that faces away from the substrate, whereby the heating/cooling plate is essentially opaque for the radiation of the second radiation source, and the heating/cooling plate is heated at least partially during the thermal treatment via the second heat source.

19. Method according to one of the preceding claims, characterized in that the second radiation source has a different wave length than does the first radiation source.

20. Method according to one of the preceding claims, characterized in that the at least one substrate is spaced from the heating/cooling plate at least during a portion of the heating phase at a distance between 50µm and 1mm.

21. Method according to one of the preceding claims, characterized in that the at least one substrate is spaced from the heating/cooling plate during an initial portion of the heating phase at a distance between 50µm and 1mm, and during the following portion of the heating phase is supported at a greater distance from the heating/cooling plate.

22. Method according to one of the preceding claims, characterized in that the substrate is rotated at least during portions of the thermal treatment.

23. Method according to claim 18, characterized in that the substrate is rotated with a rotating sound field.

24. Method according to claim 18, characterized in that the substrate is rotated by rotation of the heating/cooling plate and/or by rotation of at least one ultrasonic electrode.

25. Method according to claim 18, characterized in that the substrate is rotated by a gas stream directed thereon.

26. Method of thermally treating disk-shaped substrates, especially semiconductor wafers, in a rapid heating unit, whereby at least one substrate is heated, in a heating phase, by a radiation source that is spaced from the substrate, and is cooled in a cooling phase that follows the heating phase, characterized in that the substrate is supported in the rapid heating unit by ultrasonic levitation during the thermal treatment.

27. Method according to claim 26, characterized in that the distance between a first ultrasonic electrode and a substrate is altered during the thermal treatment.

28. Method according to claim 27, characterized in that at least during a portion of the cooling phase, the substrate is spaced from a heating/cooling plate by a distance of between 50μm and 1mm, in particular between 150 and 500 μm.

29. Method according to one of the claims 26 to 28, characterized in that the heating/cooling plate has at least one first ultrasonic electrode.

30. Method according to claim 29, characterized in that the first ultrasonic electrode has at least one flat radiation surface that essentially corresponds to the shape and size of the substrate.

31. Method according to claim 30, characterized in that the first ultrasonic electrode has at least one radiation surface that is inclined relative to the flat radiation surface and by means of which the substrate is supported in a prescribed lateral position.

32. Method according to one of the claims 29 to 31, characterized in that at least one second ultrasonic electrode is provided that is angled and/or movable relative to the first ultrasonic electrode.

33. Method according to claim 32, characterized in that the substrate is supported by the second ultrasonic electrode in a prescribed lateral position.

34. Method according to one of the claims 26 to 33, characterized in that during an initial portion of the cooling phase, the substrate is spaced from the heating/cooling plate by a distance of between 50μm and 1mm, and during the following portion of the cooling phase is supported at a greater distance relative to the heating/cooling plate.

35. Method according to one of the claims 26 to 34, characterized in that the substrate is spaced from the heating/cooling plate at a distance of between 50µm and 1mm until it has essentially reached the temperature of the heating/cooling plate.

36. Method according to one of the claims 26 to 35, characterized in that the heating/cooling plate has a thermal mass that is considerably greater than that of the substrate.

37. Method according to one of the claims 26 to 36, characterized in that the temperature of the heating/cooling plate is controlled.

38. Method according to one of the claims 36 to 37, characterized in that the heating/cooling plate is essentially transparent for the radiation of the radiation source.

39. Method according to claim 38, characterized in that for the heating of the heating/cooling plate, a fluid that is essentially opaque for the radiation of the radiation source is introduced into a chamber of the heating/cooling plate.

40. Method according to claim 38, characterized in that during a direct radiation heating of the substrate by the radiation source,

a fluid that is essentially transparent for the radiation thereof is introduced into a chamber of the heating/cooling plate.

41. Method according to claim 37, characterized in that for the cooling of the heating/cooling plate, a fluid is conveyed through a chamber of the heating/cooling plate.

42. Method according to one of the claims 26 to 41, characterized in that the heating/cooling plate is essentially opaque for thermal radiation originating from the substrate.

43. Method according to one of the claims 26 to 42, characterized in that at least one second radiation source is provided on that side of the heating/cooling plate that faces away from the substrate, whereby the heating/cooling plate is essentially opaque for the radiation of the second radiation source, and the heating/cooling plate is heated at least partially by the second heating source during the thermal treatment.

44. Method according to one of the claims 26 to 43, characterized in that the second radiation source has a different wave length than does the first radiation source.

45. Method according to one of the claims 36 to 44, characterized in that at least during a portion of the heating phase, the at least one substrate is spaced from the heating/cooling plate by a distance of between 50µm and 1mm.

46. Method according to one of the claims 26 to 45, characterized in that during an initial portion of the heating phase, the at least one substrate is spaced from the heating/cooling plate at a distance of between 50µm and 1mm, and during the following portion of the heating phase is spaced from the heating/cooling plate at a greater distance.

47. Method according to one of the claims 26 to 46, characterized in that the substrate is rotated at least during portions of the thermal treatment.

48. Method according to claim 47, characterized in that the substrate is rotated by a rotating sound field.

49. Method according to claim 47, characterized in that the substrate is rotated by rotation of the heating/cooling plate and/or by rotation of at least one ultrasonic electrode.

50. Method according to claim 47, characterized in that the substrate is rotated by a gas stream directed thereon.

51. Apparatus (1) for the thermal treatment of disk-shaped substrates (14), especially semiconductor wafers, in a rapid heating unit having at least one first radiation source (6), spaced from the substrate, for heating at least one substrate (14), characterized by at least one first ultrasonic electrode (16; 20; 26; 40) for the non-contact support of the substrate (14) in the rapid heating unit.

52. Apparatus (1) according to claim 51, characterized in that the first ultrasonic electrode (16; 20; 26; 40) has at least one flat radiation surface that corresponds to the shape and size of the substrate.

53. Apparatus (1) according to claim 51 or 52, characterized by a control device for operation of the first ultrasonic electrode (16; 20; 26; 40) in the short-range field for the support of the substrate at a distance of between 50μm and 1mm, especially between 150 and 500 μm, over the ultrasonic electrode.

54. Apparatus (1) according to one of the claims 51 to 53, characterized in that the first ultrasonic electrode (16; 20; 26; 40)

forms a heating/cooling plate or is in thermally conductive contact with a heating/cooling plate (42), whereby the heating/cooling plate has a thermal mass that is considerably greater than that of the substrate (14).

55. Apparatus (1) according to claim 54, characterized in that the first ultrasonic electrode is a coating (44) on the heating/cooling plate (42).

56. Apparatus (1) according to one of the claims 51 to 55, characterized in that the first ultrasonic electrode (20; 40) has at least one radiation surface (22) that is inclined relative to the flat radiation surface.

57. Apparatus (1) according to one of the claims 51 to 55, characterized by at least one second ultrasonic electrode (18; 29) that is angled and/or movable relative to the first ultrasonic electrode.

58. Apparatus (1) according to claim 57, characterized in that the second ultrasonic electrode has a ring-shaped form (18; 29).

59. Apparatus (1) according to claim 57, characterized by at least three second ultrasonic electrodes (18; 29) disposed on a circular line.

60. Apparatus (1) according to claim 59, characterized in that the second ultrasonic electrodes (18) are movable radially relative to a center point of the circular line and/or are movable vertically.

61. Apparatus (1) according to one of the claims 56 to 60, characterized by a control device for controlling the second ultrasonic electrode (18; 29) in such a way that it produces a rotating sound field.

62. Apparatus (1) according to one of the claims 51 to 61, characterized in that at least one second ultrasonic electrode (29) is disposed on a compensation ring that radially surrounds the substrate.

63. Apparatus (1) according to claim 62, characterized in that the ultrasonic electrode (29) is inclined relative to a plane of the compensation ring (30).

64. Apparatus (1) according to one of the claims 51 to 63, characterized by a device for the control of the temperature of the heating/cooling plate.

65. Apparatus (1) according to one of the claims 51 to 64, characterized in that the heating/cooling plate is essentially transparent for the radiation of the radiation source.

66. Apparatus (1) according to one of the claims 51 to 65, characterized in that the heating/cooling plate is essentially opaque for thermal radiation originating from the substrate.

67. Apparatus (1) according to one of the claims 51 to 66, characterized in that at least one second radiation source (46) is provided on that side of the heating/cooling plate facing away from the substrate (14), whereby the heating/cooling plate is essentially opaque for the radiation of the second radiation source.

68. Apparatus (1) according to claim 67, characterized in that the second radiation source (46) has a different wave length than does the first radiation source (6).

69. Apparatus (1) according to one of the claims 51 to 68, characterized by a device for the generation of a rotational impulse for the substrate.

70. Apparatus (1) according to claim 69, characterized in that the device has a control device for the generation of a rotating sound field.

71. Apparatus (1) according to claim 69, characterized by a mechanism for the rotation of the heating/cooling plate and/or of at least one ultrasonic electrode about a prescribed point of rotation.

72. Apparatus (1) according to claim 69, characterized by at least one gas nozzle directed onto the substrate.

73. Apparatus (1) according to claim 72, characterized in that the gas nozzle that is directed onto the substrate is disposed on a heating/cooling plate, an ultrasonic electrode and/or a compensation ring that surrounds the substrate.